

CERN STUDY GROUP ON FUSION

Second Meeting

Geneva - 11 and 12 December, 1958

MINUTES

Chairman : J.B. Adams

<u>Attendance:</u>	Ch. Lafleur	Université Libre de Bruxelles	Belgium
	C.F. Wandel	Risø Research Center	Denmark
	F. Prévot	C.E.A. Saclay	France
	A. Samain	" "	"
	M. Trocheris	" "	"
	S.D. Winter	" "	"
	P. Hubert	C.E.A., Fontenay-aux-Roses	"
	G. Vendryes	" " "	"
	L. Biermann	M.P.I., Munich	German Fed. Rep.
	G. von Giercke	" "	" " "
	K. Hain	" "	" " "
	W. Fucks	Technical University, Aachen	" " "
	H.L. Jordan	" " "	" " "
	B. Brunelli	Rome University	Italy
	E. Persico	" "	"
	J. Kistemaker	Amsterdam	Netherlands
	D. Th. J. ter Horst	Kema, Arnhem	"
	H.C. Brinkman	Delft	"
	C.M. Braams	Utrecht University	"
	K. Johnsen	Technical University, Trondheim	Norway
	A. Dattner	Technical University, Stockholm	Sweden
	L. Högberg	Uppsala University	"
	H. Knoepfel	E.T.H. Zürich	Switzerland
	R. J. Bickerton	A.E.R.E., Harwell	United Kingdom
	R. Latham	Imperial College, London	" "

Attendance (cont'd):

J. Guéron	EURATOM
D. Palumbo	"
P. J. Frank	O. E. E. C.
L. Kowarski	"
A. S. Bishop	U. S. A. E. C.
J. B. Adams	CERN
C. J. Bakker	"
J. G. Linhart	"
G. L. Munday	"
E. Regenstreif	"
A. Schoch	"

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1. AVAILABLE REPORTS

The following reports have been circulated inside the Group:

1. Remarks on the Stellarator Scheme by members of the M.P.I., Munich.
2. Brief Review of the Toroidal Stabilised Pinch, by R.J. Rickerton, Harwell.
3. Report on Linear Pinch Devices, by R. Latham and J.A. Nation, Imperial College.
4. Les machines à miroirs magnétiques, par M. Bineau, T. Consoli, F. Prévot, P. Ricateau, C.E.A.
5. Les machines à miroirs magnétiques, Résumé et Esquisse d'un Programme de Recherches, par M. Bineau, T. Consoli, P. Hubert, F. Prévot, P. Ricateau, A. Samain, C.E.A.
6. La machine d'Osovetz, par Ch. Maisonnier, C.E.A.
7. Notes on fast Magnetic Compression of Plasmas, by H.L. Jordan, H. Kever and K. Schindler, Technical University, Aachen.
8. Confinement and Heating of Plasma by R.F. electromagnetic fields, by C.M. Braams and J.C. Terlow, F.O.M. Instituut voor plasma-fysica, Rijnhuizen, Jutphaas.
9. Relativistic Electron Beam Devices for Fusion, by J.G. Linhart and A. Schoch, CERN.
10. Notes on some Theoretical Investigations of the Physics of High Temperature Plasmas, by members of the M.P.I., Munich.
11. A Compilation of Cross Sections and Rates of Interest in Controlled Therm. Nuclear Research, by the Risø Study Group.
12. The Betatron Method of Heating a Plasma to High Temperatures, by G.I. Budker, translated from Russian.

13. The Instability of a Plasma in a Magnetic Field in the Presence of Ionic Beams, by Kadomtsov, translated from Russian.
14. The Physics of Plasmas, U.S.S.R. Academy of Sciences. Abstracts of 4 volumes, translated from Russian.
15. Plasma Diagnostics by Spectroscopical Means, by H.Wulff, M.P.I.
16. Detection of Heavy Particles in Thermo-Nuclear Reaction Experiments by L.H.Th. Rietjens and C.M.Braams, F.O.M. Instituut voor plasma-fysica.
17. High Speed Photography, by A.Folkierski, Imperial College.
18. Les sources d'ions et de plasma, par T.Consoli, P.Hubert, R.Le Quinio, D.Véron, C.E.A.
19. Short Note on Energy Storage, by D.Th.J. ter Horst, KEMA.
20. Ultra High Vacuum Technology, by G.L.Munday, CERN.
21. High Magnetic Fields, by S.Berglund, Uppsala Institut of Physics.
22. Investigation in Magneto-Hydrodynamics and Plasma Physics of Interest to the Thermo-Nuclear Problems by H.Alfen, Technical University, Stockholm.

Further translations of Russian reports can be prepared to a limited extent. Suggestions should be sent to Dr. P.J.Frank, O.E.E.C.

## 2. TECHNICAL SESSIONS.

Note: The talks given by various participants are essentially covered by the reports listed above.

Biermann and v.Giercke reported on Stellarator-type devices.

Latham reported on linear pinch devices.

Bickerton summarized the toroidal pinch work.

Sanain and Prévot reported on magnetic mirror machines.

Jordan reported on fast magnetic compression.

Braams considered RF confinement and heating.

Linhart and Schoch reported on relativistic beam devices.

Hain considered various theoretical aspects of plasma physics.

Dattner gave an account of microwave techniques.

Jordan considered some aspects of mass spectrometers.

Prévot and Hubert reported on ion sources.

ter Horst reported on energy storage.

Munday reported on high vacuum problems.

### 3. ORGANIZATIONAL PROBLEMS.

#### a) Review of the situation.

Adams reviewed the situation in the light of the work carried out by the various centers.

Although the final goal of building a power delivery fusion reactor should always be kept in mind, the present stage of development would suggest not to embark in Europe on very large scale reactor projects but rather attack plasma physics on a broad front in order to get a clearer understanding of the processes leading to controlled fusion reactions. The results of these studies may suggest in a few years time the most promising devices to be considered. This line of progress would also allow small laboratories to contribute to the best of their abilities whereas the position of the small laboratories scattered through Europe would be difficult if a large size reactor were considered. Above all, however, there is a very urgent need in Europe to create facilities and train people; on account of this, devices should have only second priority.

If in the course of time the existing laboratories find difficulties in creating large facilities, it may be worth while to set up a very large centre for fusion problems in the way that CERN is a centre for high energy physics.

#### b) Evaluation of facilities.

##### bl) U.S.A. facilities.

The following table summarizes the US AEC facilities in the field of controlled fusion research (see "Research on Power from Fusion and other Major Activities in the AEC Program Jan.-June 1958").

1958	A.E.C.	Million Dollars	Scientific Staff
	Los Alamos	3	
	Oak Ridge	3.5	
	Princeton	5.8	
	Livermore	6.5	
	Other Sites	1.2	
	Total	20.--	255

The A.E.C. effort in 1959 is estimated as 39 M.dollars and a total scientific staff of 306. The investment has practically doubled every year since the inception of the fusion programme and is still in its exponential phase of growth in 1959.

## b2) European facilities.

Some preliminary figures of the European effort on fusion were recorded as follows:

Centre	1958		1959		Main interest of work
	Scientific Staff	Million Dollars	Scientific Staff	Million Dollars	
U.K. AERE) AWRE) AEI )	120	3	150	6	<u>Large size toroidal pinch.</u> Mirror machines. Linear pinch.
France CEA	40	1	70	2.5	<u>Medium size linear pinch.</u> <u>Mirror machines.</u> Microwaves, Ion sources, Basic plasma physics.
German Fed. Rep. Munich Jülich	40	1	120	3.5	<u>Stellarator devices.</u> Linear pinch. Diagnostic techniques. Theoretical effort.
Total	200	5	340	12	

It was generally felt that the amount of overlapping between the larger centres is a healthy one and that very little need arises at the moment for a still larger European laboratory.

There are also many smaller laboratory groups working in this field:

Group	1958		1959		Main interest of work
	Scientific Staff	Million Dollars	Scientific Staff	Million Dollars	
Dutch	18	0.25	30	0.5	Slow linear pinch, RF confinement Ion magnetron, Heating processes, Storage problems.
Aachen (Jordan)	30	0.25	45	1.25	Fast compression devices, relativistic electrons, high fields, diagnostic techniques.
Stockholm Uppsala	25 15	0.25 0.1	30-35		Basic plasma physics, homopolar devices, plasma filled waveguides, linear pinch, storage problems.
Rome	6	0.15	12	0.35	Basic plasma physics
London + others	11 20	0.07 0.1			Linear pinch, fast photography shock waves, spectroscopy
Brussels			6	0.07	In stage of inception
Zürich			15	0.05	In stage of inception

## c) Discussions.

Guéron summarized the Euratom position.

The Euratom treaty provides a research and investment fund over the first five years, to be spent partly by placing research contracts, partly by participating in nuclear ventures in various countries (not necessarily Euratom members) and partly by Euratom itself, in its common research centre. From the research and investment fund 12 Mill. dollars have been allocated to fusion work but no commitments have been taken as yet. The general Euratom policy is to build up something rather impressive (large research centres) and to increase the efficiency without frustrating individuals or established laboratories. A big contract on fusion work is now being placed with France, another is being contemplated with Germany. Joint financing and joint management are provided in these contracts, actual work being carried out by mixed groups. Subcontracts will be handled on a local basis.

A teaching system has been set up in Saclay involving a 5 months course on fusion starting in January 1959. Although this works on a national scheme, the Commission has decided to offer 5-6 scholarships to young students, provided there is agreement from the C.E.A. (in addition to the course the students should devote part of their time to actual work inside the C.E.A.). Nationals from countries outside Euratom are certainly not excluded.

Biernam pointed out that a similar teaching scheme has been set up at Munich. Fellowships are available on a national and international basis.

Bishop stressed the importance of frequent meetings to exchange information and stimulate comments and criticism. This has proved extremely fruitful in the case of the Sherwood Project.

Kowarski stated that O.E.E.C. had no contribution to make at this stage, he wished however to express his personal views: a) Western Europe should not "compete" with the nations most actively engaged in the field. An effective European contribution can be made in a way "complementary" to the U.S. effort. This requires prior consultation, choice of objectives which would interest all parties concerned, and of course an effective exchange of information. b) The experience of CERN shows that a willing support of European scientists and technicians, an adequate financial support and a cooperative response in the U.S. can be best obtained by building up the European effort around a big material object (a thermonuclear device or an experimental facility). It may easily be found that such objects can be built only on an all-European basis; in this case the necessity for creating a European thermo-nuclear research centre would arise. c) CERN has experience and a personnel well-trained in the design and construction of big electromagnetic devices; these assets would have to be used in some way.

Bickerton pointed out that a very large power supply system, involving 3-4 years of development work could well be an undertaking around which the various devices could be located. This would have the advantage of committing fusion work only to magnetic confinement, but not to a particular device.

4. OTHER BUSINESS.

The next meeting will take place on 19 and 20 March, 1959, at Geneva.

The various groups should send in their up to date reports.

Adams will write a draft report based on discussions of the Study Group. This report will be sent to all members for comments so that agreement on the final Study Group report can be reached at the next meeting.

The various groups are encouraged to consider the problem of a large power supply. In particular, a more detailed report is expected from KEMA.

It was agreed that **Saclay** and Munich should make available to all members the programmes of their courses.

E.R.

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